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Soil Survey
of
The Nogales Area, Arizona

By

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Bureau of Chemistry and Soils

In cooperation with the
University of Arizona Agricultural Experiment Station

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SOIL SURVEY

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SOIL SURVEY OF THE NOGALES AREA, ARIZONA

By T. W. GLASSEY

AREA SURVEYED

The Nogales area covers the agricultural lands in the western half of Santa Cruz County, Ariz., and extends across the county from the southern to the northern boundaries. (Fig. 1.) The county, which is the smallest in the State, is situated in the extreme southern part of the State about 80 miles west of its southeastern corner. From Nogales, the area extends along the Mexican boundary for about 9 miles, but it narrows to 1½ or 2 miles in width 3 miles north of Calabasas and continues at that width to its northern extremity. Nogales, the county seat of Santa Cruz County, is 68 miles south of Tucson and about 60 miles west and southwest of Bisbee and Tombstone, respectively. The area surveyed covers 62,080 acres, or 97 square miles.

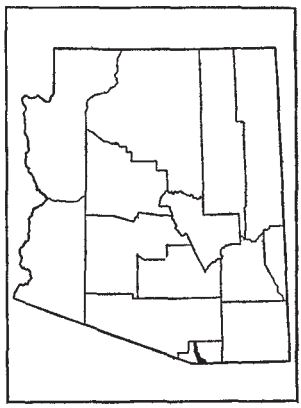

FIGURE 1.—Sketch map showing location of the Nogales area, Arizona

The Nogales area includes the long narrow valleys along Santa Cruz River and Nogales Wash, which range from a quarter of a mile to about 1½ miles in width, with intervening and adjacent areas of desert and grazing lands. Along the sides of the area are benches, or narrow terraces, that slope back as narrow ridges and spurs to the mountains on both sides of the valley. Between Nogales Wash and the river in the southern part of the area the ridges extend toward the center, culminating in Mount Benedict.[1] This area between the wash and the river is composed of tuffaceous conglomerates and sandstones, whereas the rest of the terraces along the valley are covered by old stream deposits.

Santa Cruz River, which rises in the eastern part of Santa Cruz County, at the southern base of the Canelo Hills, flows south into Mexico and makes a 30-mile loop before reentering the United States 6 miles east of Nogales. The river waters sink into the sand and flow underground for most of their course through the area.

The main Santa Cruz Valley is a flat valley composed of recent stream deposits, with the stream bed lying in a well-defined channel from 15 to 25 feet deep. The valley is well drained except in a flat area of heavy-textured soil northwest of Calabasas and another

[1] BRYAN, K. THE PAPAGO COUNTRY, ARIZONA: A GEOGRAPHIC, GEOLOGIC AND HYDROLOGIC RECONNAISSANCE WITH A GUIDE TO DESERT WATERING PLACES. U. S. Geol. Survey Water-Supply Paper 499, 436 p., illus. 1925.

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southeast of Tubac. Nogales Wash is a narrow stream bottom, not more than one-half mile wide at any place, in which the stream channel is inclosed between steep banks from 10 to 15 feet high. In places in the valley seepage water rises to the surface, giving rise to poorly drained conditions. The lower part of the valley is composed of heavy-textured soil, and most of the land is poorly drained. Most of the marginal terraces and ridges of Nogales Wash and Santa Cruz Valley are narrow and deeply gullied, and a rough surface has resulted, suitable only for grazing purposes, with a few included stream valleys wide enough to map.

The elevation of the lower part of the Santa Cruz Valley is about 3,100 feet above sea level. The highest point in the area surveyed is Mount Benedict which is 4,500 feet high. Nogales has an elevation of 3,840 feet, and the point where Santa Cruz River enters the area and the United States, 6 miles east of Nogales, is about 3,700 feet high. At Calabasas, 9 miles north of Nogales, the elevation drops to 3,433 feet. The terraces and ridges along the edge of the valley are from 25 to 75 feet above the valley floor.[2]

The main trees on the long sloping terraces on the east side of Santa Cruz River, extending from the Patagonia Mountains to the river, are bellota oak (*Quercus ilex*) and blue oak (*Q. douglasi*). These trees are less numerous west of the river as far as Nogales Wash. The principal grasses are annual false needle grass and six-weeks grama. They do not have a high grazing value and grow on sandy and gravelly soil. Mesquite is the most common shrub or tree and grows in all parts of the area but does best in low canyons or bottoms where water from seepage is more abundant. Under these conditions mesquite grows to a height of 20 feet or more. In places it forms a dense cover; in others an open regularly-spaced growth. Yucca, the pricklypear form of cactus, and ocotillo grow between the river and Nogales Wash. Here, and east of the river, the most common forms of grass are six-weeks grama, hairy grama, and side-oats grama, which make better grazing than the other kinds of grass growing on the loose sandy and gravelly soils.

The valley parts of the Nogales area contain numerous cottonwood, common river-valley willow, Arizona blue elderberry, mesquite, and other trees, squaw bush, and an evergreen shrub that came in from Mexico, *Senecio saligna*. A very few western walnuts grow here and there along the river and Nogales Wash. The several varieties of grama and Johnson grass grow along the bottoms, and the alluvial fans and slopes marginal to the gravelly and sandy stream bottoms are covered, for the most part, with annual false needle grass and six-weeks grama. The alkali-affected and other poorly drained areas support a coarse bunch grass, representing species of Sporobolus or Muhlenbergia, and a form of saccaton grass grows on spots having alkali accumulation.[3]

The vegetation gradually changes in the vicinity of Tubac, with decrease in elevation and rainfall, increase in annual mean temperature, and distance from the higher mountains. Paloverde and barrel cactus begin to appear on the gravelly slopes, with ocotillo on the higher ridges. Goat grass takes the place of the larger false

[2] See footnote 1, p. 1.
[3] Plant specimens were identified by J. J. Thornber, University of Arizona.

needle and six-weeks grama grasses on the gravelly and sandy soil on the slopes.

The Santa Cruz Valley was originally inhabited by the Sobaipuris tribe of Indians who carried on a crude form of agriculture, producing corn, beans, melons, and cotton along Santa Cruz River near the present Tumacacori National Monument, where the Indians had a village. Here the Indians were found in 1691 by Father Eusebio Francisco Kino, who was the first white man to enter the valley. His purpose was to convert the Indians and explore the country. In 1700, Kino established San Xavier Mission, which is located about 25 miles north of the Nogales area. The following year a mission was started at the present site of Calabasas.

Cattle, sheep, and goats were placed with the Indians at San Xavier by Kino in 1697, and this was the beginning of the livestock industry of Arizona. Under the direction of the Jesuit missionaries the Santa Cruz Valley became an important livestock-raising and farming community.

The Spanish authorities established a presidio at Tubac in 1752 to protect the settlers of the valley from the Apache Indians. In 1776 the garrison was transferred to Tucson. Calabasas was settled before 1760 but was deserted 17 years later. The Santa Cruz Valley was under Mexican rule following separation of that country from Spain, and following the Gadsden Purchase in 1853 passed under American control. Two years later American troops replaced the Mexican troops at Tubac, and the first newspaper in Arizona was published in this town in 1858. Before and after the Civil War mining operations were developed in this and other parts of Arizona, but owing to the depredations of the Apache Indians rapid settlement was prevented until 1874, when the Indians were brought under control.[4]

Following the Gadsden Purchase the United States customhouse was located at Calabasas, which was at that time the most important town. The customhouse was later moved to Nogales, which was founded after 1880. The railroad from Benson, Ariz., northeast of Nogales, to Guaymus, Sonora, Mexico, was completed to Nogales in 1882. Nogales became the division point of the main railroad down the west coast of Mexico to Mexico City.[5]

By 1890 the population of Nogales had increased to 1,194, owing to the growth of imports and exports from and to Mexico after the completion of the railroad and establishment of the customs service at Nogales.

Santa Cruz County was organized as a county from a part of Pima County in 1899. In 1900 the county had a population of 4,545, which increased to 6,766 in 1910 and to 12,689 in 1920, but decreased to 9,684 in 1930. The population, according to the 1930 Federal census, is 35 percent native white, 4.6 per cent foreign-born white, 7.4 per cent negro, and 53 per cent of other races, mainly Mexican and Spanish-American. Spanish is the common language spoken by the inhabitants of Santa Cruz County and the Nogales area. Nearly two-thirds of the population of the county is located in the

[4] McCLINTOCK, J. H. ARIZONA, PREHISTORIC, ABORIGINAL, PIONEER, MODERN, THE YOUNGEST STATE. 3 v. illus., Phoenix, Ariz. 1916.

[5] BRISTOL, J. B. HISTORY OF NOGALES. With autobiography by Sarah Renshaw.

town of Nogales. Tubac and Amado are small towns within the area. The rest of the population resides on farms, in mining camps, and small settlements scattered along the valleys.

The main line of the Southern Pacific Railroad in Mexico and down the west coast of the United States reaches Nogales from Tucson which is farther up the Santa Cruz Valley. The original railroad from Benson connects with the present main line at Calabasas after touching Patagonia to the east. Nogales is the most important port of entry for imports from Mexico entering Arizona and one of the most important in respect to value of imports from Mexico to the United States. More than 5,000 carloads of fresh vegetables from Mexico passed through Nogales during the winter season of 1929–30. The Nogales area is served by improved State highways, one traversing the Santa Cruz Valley to Tucson and another to Patagonia and Tombstone to the east. Schools and churches are established in almost all parts of the area. Only a small number of the homes outside of the towns are served by telephone.

The main industry of the county is mining copper and a very little lead and silver in the mountains, along Santa Cruz Valley, and in other parts of the county. The mining, importing, and exporting industries support a large part of the urban population, and a local market is thus provided for certain farm products, such as dairy and poultry products and vegetables. Travel from and into Mexico as well as the United States Army post at Camp Steven D. Little, at the edge of Nogales, helps to swell the transient population of Nogales.

CLIMATE

The climate of the Nogales area is characterized by a large percentage of sunshine, low rainfall, and low relative humidity. The season of greatest rainfall is from the last of June through July, August, and part of September, when the average monthly rainfall at Nogales for these months is 0.43, 3.42, 3.48, and 1.68 inches, respectively. Excepting the month of January, the rest of the year is very dry, with an average of less than an inch of rain for each month. The average rainfall for the year is 14.19 inches.

The wind velocity is generally moderate, except in the spring and early summer, when strong winds are of common occurrence. Air currents are usually from the south.

The elevation of the part of the Santa Cruz Valley included in the Nogales area ranges from about 3,100 feet above sea level to more than 3,800 feet, which is about 1,400 feet higher than Tucson, 68 miles to the north in the lower Santa Cruz Valley.[6] The average annual rainfall is 2.34 inches less at Tucson than at Nogales, and this would probably indicate at least 1 inch less rain in the northern part of the area than at Nogales. The elevation being higher than in the greater part of southern Arizona causes this area to have a cooler summer and a little colder winter. During the summer the days are hot but the nights are cool, making the area a more desirable place to live in than the lower elevations. The maximum summer temperature at Nogales is 110° F., recorded in June, and the minimum temperature is 10° in February. The mean annual

[6] UNITED STATES GEOLOGICAL SURVEY. NOGALES AND PATAGONIA QUADRANGLES. U. S. Geol. Survey Sheets. 1905.

temperature is 61.8°, and the frost-free season extends over a period of 222 days. The latest frost ever recorded was May 19 and the earliest was October 14.

The cooler climate, owing to the elevation, prevents the growing of citrus fruits and winter vegetables but provides conditions favorable to an earlier fall and later spring season for the growing of lettuce than do other lettuce-producing sections of the State, in which temperatures may be excessive for this crop late in the fall and early in the spring. This is an advantage in that it places lettuce on the market when lettuce from other sections of the State is not available.

The climate is not cold enough to prevent farm work being done during the winter. Small grains, as barley, are usually sown in the fall. Owing to the mild weather, people from colder regions spend their winters in the Nogales area and Santa Cruz County to some extent.

The normal monthly, seasonal, and annual temperature and precipitation, as recorded at the United States Weather Bureau station at Nogales, are given in Table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Nogales, Ariz.*

[Elevation, 3,600 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1924)	Total amount for the wettest year (1927)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	46.5	84	12	0.90	0.32	1.94	0.8
January	45.8	83	14	1.21	.11	(1)	.9
February	49.2	88	10	.69	(1)	1.10	.9
Winter	47.2	88	10	2.80	.43	3.04	2.6
March	52.8	90	12	.66	2.61	1.37	.4
April	59.3	93	20	.29	.01	.65	(1)
May	66.0	104	24	.13	(1)	.14	0
Spring	59.4	104	12	1.08	2.62	2.16	.4
June	76.2	110	40	.43	.23	1.19	0
July	78.7	108	51	3.42	1.85	4.76	0
August	76.8	102	49	3.48	2.26	5.57	0
Summer	77.2	110	40	7.33	4.34	11.52	0
September	73.0	103	36	1.68	1.98	3.43	0
October	63.5	96	26	.52	0	.47	(1)
November	54.1	90	14	.78	0	.42	.2
Fall	63.5	103	14	2.98	1.98	4.32	.2
Year	61.8	110	10	14.19	9.37	21.04	3.2

[1] Trace.

AGRICULTURE

Before 1900 agriculture in Santa Cruz County was carried on mainly along the bottoms of Santa Cruz River, Nogales Wash, and Sonoita Creek. In 1900 only 113 farms existed in the county, with an average of 445 acres to the farm, of which an average of 39.2

acres were improved. The value of the livestock sold and slaughtered in 1899 was the largest item of income, $132,636, with dairy products valued at $4,541 and poultry at $1,552. The main crops were grains cut for hay, which occupied 1,051 acres; alfalfa, with an acreage of 366 acres; other tame grasses, 169 acres; coarse forage, grown on 338 acres; wild grasses, on 326 acres; corn for grain, on 123 acres; and a small acreage was devoted to oats, wheat, potatoes, peaches, and apples.

Ten years later (1909) the value of poultry and eggs was $10,658; the value of dairy products, excluding home use, decreased to $3,245; and the value of livestock sold and slaughtered increased to $176,238. Corn was grown on 901 acres, grain cut for hay on 2,354 acres, beans on 364 acres, potatoes on 34 acres, and miscellaneous vegetables were listed for the first time, with 96 acres. Alfalfa, millet, other tame grasses, and coarse forage decreased in acreage. Wheat, barley, and milo sorghum were produced to some extent for grain.

Fruits had become of some importance, and there were 2,215 apple trees, 622 peach trees, 168 apricot trees, 1 acre in strawberries, 158 grapevines, and a few pear, plum, and cherry trees.

The number of farms increased to 176, and the average size decreased to 294.7 acres, evidently due to dividing the farms along the river bottoms where irrigation was carried on. During this decade (1900–1910) the percentage of farms operated by owners decreased slightly, and the percentage operated by tenants doubled.

The census of 1920 showed an increase in the number of farms to 248 and an acreage increase to 607.2 acres a farm. The percentage of improved land increased from 11.7 percent to 16.6 per cent of the farm. The value of farms and farm property increased, although the acre value of land showed a slight decrease, owing to the fact that more rough land was brought under private ownership. The percentage of farms operated by the owners increased slightly.

During the decade from 1910 to 1920 there was a great increase in the acreage of crops in Santa Cruz County. Milo was grown on 2,893 acres, tame grasses on 1,306 acres, corn on 1,798 acres, alfalfa on 243 acres, coarse forage on 942 acres, and beans on 676 acres. The average acre yields of most crops decreased.

The total value of all agricultural products increased from $300,541 in 1909 to $1,683,191 in 1919. The value of domestic animals made the largest increase, reaching $1,295,514. The value of dairy products increased from $3,245 to $44,093. The value of fruits increased from $4,328 to $6,549. Most of the other products doubled or tripled in value.

The census of 1930 reports 220 farms in the county, with an average size of 1,152.9 acres. The percentage of farms operated by owners is 78.6 per cent, by tenants 19.6 per cent, and by managers 1.8 per cent. The average value of land and buildings a farm was $8,352 in 1930. In 1929, $72,487 was spent for feed and $73,834 for labor. Most of the laborers hired are Mexican cowboys who are employed on the large cattle ranches at wages ranging from $35 to $40 a month. Very little commercial fertilizer is used.

Crop figures taken from the Federal census for Santa Cruz County apply fairly closely for the Nogales area, but some of the crops are grown to some extent in other parts of the county. The crops and

industries mainly restricted to the area surveyed are dairying and the production of alfalfa, corn, oats, barley, wheat, grains cut green, potatoes, vegetables, and various fruits. Cattle, other than dairy animals, are raised almost exclusively outside the Nogales area.

At the present time the main crops grown in the valleys of Santa Cruz River and Nogales Wash are barley for hay, hegari, milo, corn, Amber (sorgo) cane, Sudan grass, Johnson grass, lettuce and other vegetables, cotton, alfalfa, beans, and potatoes.

Farming is almost exclusively carried on by the owners. Rentals are usually for cash. A few of the larger ranches are under the care of a manager as some of the owners are nonresidents.

The greatest hindrance to the development of agriculture of the Nogales area was defective land titles to the upper Santa Cruz Valley from Tubac to Calabasas. This caused a large number of people to move out, and for several years the land was left idle. A large acreage is still in that condition.[7]

Dairying is the principal industry within 10 miles of Nogales along Nogales Wash and the near-by Santa Cruz Valley to the northeast and east. The dairy herds range in size from 15 to 40 cows. No special breed or improved dairy type of cattle is used. The main market for dairy products is Nogales, where most of the milk is retailed as whole milk or cream. The main part of the land along Nogales Wash is used to grow barley, Amber cane, corn, and Johnson grass, for hay and fodder for the dairy cows. Grain and other concentrates are shipped into the area from other places.

In the same localities are several commercial poultry farms, as well as many small flocks that produce eggs for the Nogales market.

Farther north, from Calabasas to the northern boundary of the Nogales area, alfalfa and barley hay are baled and shipped to Tucson and Nogales. Cotton is taken to Continental, which is outside the area, for baling and ginning. Lettuce and other vegetables grown near Tumacacori National Monument are marketed in Nogales, and some are shipped to other markets. Cattle raised for beef are ranged on the hills, mostly outside of the area, and are fed only when the range grasses are not sufficient to nourish them. The cattle are shipped out, principally to southern California, for fattening for market. Beef-cattle production is the main industry of Santa Cruz County, but it is carried on mainly outside the area surveyed.

The agriculture of the Nogales area has been of little more than local importance in comparison with that of the rest of the State, and no special study or experiments have been carried on by the State experiment station in this county or area.

Horses and mules are the most common motive power used. Some tractors are used in farm operations and for pumping water for irrigation.

One of the most common cropping methods used by dairymen operating along the Nogales Wash is to plant barley in the fall and cut it in the spring for hay. Johnson grass, that infests the region, comes up afterwards and is also cut for hay. Alfalfa and barley, which are baled and sold as hay, together with beans and cotton, form the most important cash crops in the northern half of the area.

[7] UNITED STATES CONGRESS. EXTENDING RELIEF OF SETTLERS AND ENTRYMEN ON BACA FLOAT NO. 3, ARIZONA. U. S. Congress, 69th, 1st sess., H. R. Rpt. 275, 14 p. 1926.

Corn is usually planted from the middle of April to June 20. The main part of the crop is used as fodder, and some is placed in silos. Yields of corn are about 20 bushels of grain, or from 7 to 12 tons of green corn for silage or fodder. Mexican June is the most common variety of corn grown. The Arizona Agricultural Experiment Station recommends the use of corn and sorghums for silage. By using a trench silo it is possible for the small dairyman to put up silage without a large outlay of capital for silo equipment.

Cotton is considered a good crop for the lower part of the area. It is planted during the latter part of April or May. The main varieties of Pima cotton grown are Acala and Hartsville.

The bean grown is the common pink bean, or frijole. Beans are usually planted from May to August, under irrigation, and on land not under irrigation just before the summer rains during the early part of July. Beans yield from 8 to 12 sacks an acre.

About 35 acres were devoted to lettuce in the spring of 1930. Lettuce is usually grown on the medium-textured or heavy-textured soils, such as Pima loam, Gila loam, or Gila silt loam. In other lettuce-growing sections of the State heavy-textured soils are the main soils devoted to the crop. The Arizona Agricultural Experiment Station advocates an increase in the acreage devoted to lettuce. Onions have been successfully grown.

Sudan grass is a good short-season forage crop and may be planted at intervals during the summer.

Potatoes are grown to a limited extent. The main variety is the Irish Cobbler, with some Bliss Triumph. Experiments by the State agricultural experiment station, carried on a few miles outside of the area, have shown the Irish Cobbler to be the best potato for this area, 5,450 pounds an acre of the Irish Cobbler and 4,500 pounds an acre of the Bliss Triumph having been produced.[8] Potatoes are planted in early March and harvested after June 10. Seed potatoes are shipped in from States to the north, as Idaho and Colorado.

Alfalfa, one of the most important hay crops, especially in the northern part of the area, is one of the principal cash crops. The main varieties grown are Peruvian and Common. Five crops of alfalfa are commonly cut during the season, with total yields ranging from 2½ to 4½ tons an acre. Alfalfa is grown mainly on the lighter-textured soils in the river bottoms.

Practically all the agriculture of the Nogales area is dependent on irrigation, owing to the low rainfall and high temperature during the growing season. Water is obtained from Santa Cruz River by gravity and by pumping. Pumping is the most common source of supply. Large wells are dug into the sand-and-gravel stratum that underlies the whole valley floor, where an underground flow of Santa Cruz River occurs. The depth to water requires a lift ranging from 15 to 25 feet to place the water on the bottom land. According to the farmers, there is always an abundance of water. In previous times some of the land along the lower benches is said to have been irrigated by gravity water from ditches, taking the water out at some distance above the land on which it was to be

[8] BROWN, C. B. IRISH POTATO GROWING IN THE IRRIGATED VALLEYS OF PIMA COUNTY. Ariz. Agr. Col. Ext. Circ. 54, 25 p., illus. 1926.

used. At the present time gasoline engines and tractors are used with centrifugal pumps to pump water. The erosion and deepening of the river bed are said to have rendered many of the ditches useless.

SOILS AND CROPS

The soils dominating the alluvial valley of Santa Cruz River in the Nogales area are the Pima, Gila, and Tumacacori soils, and the land along Nogales Wash is occupied principally by the Tumacacori soils. Although the agriculture of the area is developed mostly on these soils, this is due mainly to factors other than soil fertility, as topography and elevation above the river, which make it possible to pump water from the lower gravel and sands that underlie the whole valley and apply it on the land without too much expense. The costs of labor and of leveling and preparing the land for irrigation on these soils are not excessive and have not been prohibitive to agricultural development.

As has been stated, the most important factor in preventing the development of agriculture in the part of the valley between Calabasas and Tubac on the tract known as Baca Float No. 3 has been litigation over land titles. An old Spanish land grant held originally by Luis Baca was acquired along Santa Cruz River in 1863, extending from near Calabasas to near Tubac. In 1864, the Department of the Interior refused to issue patents to the Baca heirs, claiming the land was mineral. From 1899 through several years 39 settlers homesteaded land claimed under the Baca grant and part of them received patents. On June 22, 1914, the United States Supreme Court decided that the Baca heirs had received title to the land in 1864, so on December 13, 1917, the United States District Court at Tucson gave an eviction decision against the settlers, causing them to leave the farms they had homesteaded. From that time to the present a large acreage of that part of the valley has not been farmed. At the time of the soil survey a large tract in the southern part of the old Baca grant was being cleared and leveled for cropping.[9]

The main crops of the stream bottoms on the Pima, Gila, and Tumacacori soils of medium or heavy texture are barley, hegari, milo, corn, alfalfa, cotton, beans, lettuce, and other truck crops. Nogales Wash, which is the dairy center near Nogales, is mainly an area in which barley and hegari, or other sorghums, are produced on soils of the Tumacacori series. It is an area of heavy-textured soils. The soils commonly devoted to barley, grain sorghums, corn, cotton, and lettuce are the loams, silt loams, and clay loams. With the exception of lettuce, which is grown mainly on loam, clay loam, or silty clay loam, the other crops are grown on fine sandy loams of the Gila and Pima series. Alfalfa is generally grown on the lighter-textured soils, such as Pima fine sandy loam, Gila very fine sandy loam, and Gila fine sand. It is said that the best crops of alfalfa grown on one farm are produced on Gila fine sand.

Pecan trees are being set out on areas of Gila fine sand and Pima fine sandy loam, which are some of the lightest-textured soil types farmed. The coarser-textured sandy soils are usually not farmed,

[9] See footnote 7, p. 7.

and they support only poor types of vegetation, as goat grass, rabbit bush, barrel cactus, and paloverde and mesquite trees.

Most of the Pima and Gila soils along Santa Cruz River occur in long narrow strips paralleling the river, and they do not occur in very large bodies of uniform texture. Most of the fields under cultivation include several soils of one or more soil series. This adds to the difficulty of irrigation, since the sandy soils absorb water more readily than the silt loams and clay loams. The heavier soils hold more water and require less frequent irrigations, unless they are underlain by loose sand near the surface, as is true in some places.

The only Comoro soil extensively farmed is the sandy loam, which is in grain, grain sorghum, and alfalfa, under irrigation. A little of the fine sand also is under cultivation, but most of it is covered by mesquite, cottonwood, Arizona blue elderberry, river-valley willow, and an evergreen shrub.

The Sonoita and Hesperia soils are terrace or bench-land soils and are devoted only to grazing at the present time. They are mainly loose sandy soils, and a high percentage of them is either gravelly or stony. At one time some areas of these soils were irrigated by gravity water, but the ditches have fallen out of repair and the river is said to have cut a deeper channel and become lower than the old ditches. These soils occur mainly in small bodies and may lie at elevations too great for pumping water economically from the nearest source or the porosity may be such as to require too much water for a crop. They are sloping and may be fairly steep in places. It is said that Sonoita sandy loam has been planted to beans which have produced crops in seasons of high rainfall. A heavy growth of mesquite, some squaw bush, false needle grass, and six-weeks grama grow, but they have little grazing value. A few barrel cacti and paloverde trees grow on these soils north of Tubac.

The two soils which have developed a heavy clay subsoil and are mapped as the Nogales and Tubac soils are nonagricultural, with the exception of a few fields devoted to grain sorghum, grown without irrigation, on Nogales clay loam.

The Cajon soils are represented by a single gravelly and sandy soil which is of low moisture holding capacity, is without water supply for irrigation, supports a desert vegetation, and is utilized only for grazing.

The soils of the Nogales area are classified into series on the basis of similar characteristics of color, topography, character of the subsoil, drainage, and lime content and parent materials, where affecting soil character or profile, and are given a geographic series name. The series are divided into individual soil types on the basis of texture, or the relative proportion of the different-sized mineral particles of sand, silt, and clay in the surface soil.

River wash and rough broken and stony land are nonagricultural types of miscellaneous materials.

In the following pages the soils of the Nogales area are described in detail and their agricultural possibilities are discussed; the accompanying soil map shows their location, and Table 2 gives their acreage and proportionate extent.

TABLE 2.—*Acreage and proportionate extent of the soils mapped in the Nogales area, Arizona*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Pima fine sandy loam	2,240	3.7	Comoro fine sand	832	1.4
Pima silt loam	2,176	3.5	Comoro fine sand, loose-subsoil phase	704	1.1
Pima loam	384	.6	Comoro sandy loam	448	.7
Gila fine sand	1,280	2.0	Comoro gravelly loamy sand	384	.6
Gila sand	192	.3	Comoro gravelly loamy sand, reddish-brown phase	1,344	2.2
Gila very fine sandy loam	576	.9	Cajon gravelly sand	896	1.4
Tumacacori clay loam	1,088	1.8	Hesperia loamy sand	704	1.1
Tumacacori clay loam, calcareous-subsoil phase	640	1.0	Hesperia loamy sand, compact-substratum phase	512	.8
Tumacacori sandy loam	2,880	4.6	Sonoita sandy loam	1,536	2.5
Tumacacori sandy loam, calcareous-subsoil phase	320	.5	Tubac gravelly sandy loam	768	1.3
Tumacacori silty clay loam	448	.7	Nogales clay loam	704	1.1
Tumacacori silty clay loam, calcareous phase	256	.4	River wash	3,392	5.5
Tumacacori gravelly loamy sand, dark-colored phase	1,472	2.5	Rough broken and stony land	35,904	57.8
			Total	62,080	

SOILS OF THE PIMA SERIES

The Pima soils are dark dull brown or dark grayish brown, both in the surface soil and in the subsoil. They occur along the main streams in the flatter parts of the valley. They consist of unweathered stratified stream-laid materials of recent accumulation and are calcareous throughout their profile, the lime being uniformly distributed. This is one of the main groups of soils under cultivation.

Pima fine sandy loam.—Pima fine sandy loam has a dark-brown or dark grayish-brown highly calcareous surface soil from 10 to 15 inches thick, overlying similarly colored stratified material that ranges from loam to sand or loamy fine sand in texture. The different strata are variable in lime content, and in some places lime is absent from individual strata. This soil occurs along Santa Cruz River or near it. It has been laid down by the stream during a very recent period. It has little or no compaction in the subsoil or other evidence of weathering, but it is loose and very friable.

Pima fine sandy loam occurs in different-sized bodies along Santa Cruz River from near the bend of the river south of Santa Cruz School northward to the county boundary. The largest areas are near Calabasas, and some almost as extensive occur near and north of Tumacacori and near Amado. Some areas along Sonoita Creek have a coarse sand subsoil, causing excessive porosity. This variation occurs also in other places, but the areas are too small to map.

Pima fine sandy loam has a very level surface that is easily prepared for irrigation. The land lies from 10 to 25 feet above the river, and water can be easily applied by pumping, without an excessive lift and cost of pumping.

Included within areas of Pima fine sandy loam are small bodies of Pima fine sand. The largest included body is near the road 2½ miles south of Amadoville School. Other small areas are northwest of the same school, 1 mile south of Tubac, 1¾ and 2 miles southeast of Tumacacori National Monument, 1¼ miles southeast of Calabasas, and 2¾ miles southeast of Santa Cruz School. A small area lies on the Mexican boundary west of the river.

In other localities small undifferentiated areas of Pima gravelly sandy loam are included, owing to their limited extent. The largest body, north of Chavez, covers about 100 acres. An area including about 50 acres lies across the river from Tubac, another of similar size lies northeast of Tumacacori National Monument, and two areas, including about 20 acres each, lie 2½ and 4 miles southeast of the national monument. The areas of this included soil contain coarser sand in the surface soil and gravel that does not affect its value for farming to any extent.

Pima fine sandy loam, with inclusions, covers 2,240 acres.

Pima silt loam.—Pima silt loam is almost as extensive as Pima fine sandy loam. It has a 10 or 12 inch surface soil of dark-brown silt loam overlying a stratified subsoil that consists of silt loam, fine sandy loam, or sandy layers of dark-brown material, in most places high in lime content. In places a loose sand layer lies fairly close to the surface and makes the surface soil droughty. Such areas, too small to differentiate on the map, occur at Amado and in other localities.

The surface relief is in general level, and the land is easily made ready for the application of irrigation water. The heavier texture of the surface soil causes it to take water more slowly in irrigation but it will hold more water than Pima fine sandy loam and requires less frequent irrigations. In some years of high rainfall crops have been grown without irrigation.

Areas of this soil are in the most highly developed part of the Nogales area. A few small areas lie along Santa Cruz River between Santa Cruz School and Calabasas on the north, where several larger bodies, ranging from 50 to 100 acres, occur at Calabasas and north of that place. Two miles southeast of Tumacacori National Monument a narrow strip extends along the west side of the river for more than a mile and a half. East of the river at Tumacacori National Monument an area continues along the valley to Tubac. North of Tubac are several smaller bodies.

Included with Pima silt loam in mapping are several areas of a heavier-textured Gila soil, Gila clay loam. One-half mile northwest of Chavez and extending in a northwesterly direction for three-fourths of a mile is an area including about 160 acres. North of this is a small area in much of which gravel is mixed. Southwest of Chavez, one-half mile west of the river, a strip of the clay loam extends nearly to Tubac. South of Tubac is an area of about 40 acres and another is 1¼ miles southeast of that place on the east side of the railroad. One-half mile southwest of this body is another that extends across the railroad. East of Tumacacori National Monument a narrow strip extends along the east edge of the valley for a half mile. There is a small area 1½ miles northeast of Tumacacori National Monument, and south of the national monument a small elongated body lies between the river and the Nogales-Tucson highway. Three-fourths mile northwest of Otero a 25-acre tract lies along the private road, and 1½ miles south of Otero are two small areas. The one west of the river is underlain by porous sand. East of Silva a narrow strip follows the foot of the slope occupied by Tumacacori sandy loam and rough broken and stony land, and a mile to the south about 30 acres occur along the railroad. Other

small included bodies are one-half mile southeast of Calabasas, one-half mile south of Plomo, and in the vicinity of Santa Cruz School.

One mile northeast of Tumacacori National Monument a small strip of Pima silty clay loam soil is included with Pima silt loam. It is heavier than either the silt loam or the clay loam and is harder to cultivate or prepare for irrigation. It occurs in association with Tumacacori clay loam areas and is used for the same crops. One small area 2 miles south of Otero is underlain by coarse porous sand.

Pima loam.—Pima loam has a 10 or 12 inch dark-brown calcareous surface soil overlying a similarly colored subsoil that consists of material ranging in texture from loam to sandy loam, in some places, sand. The subsoil is calcareous and more or less loose, without any compaction. In many places this layer rests on a sand and gravel bed at a depth ranging from 50 to 70 inches. In a few places this bed may be closer to the surface.

Pima loam is mainly under cultivation, owing to its desirability for cultivation and irrigation. The medium texture provides a soil of moderate water-holding capacity, which is easily worked and does not require such frequent applications or so much water to produce a crop as do the lighter-textured soils.

Under natural conditions this soil was covered by a dense growth of mesquite brush and native grasses, with some cottonwood trees and a few bushes.

Most of the soil is in the northern part of the county, where the main part of the alluvial stream-bottom soils are cleared and in crops. The main body of Pima loam is southeast of Tumacacori National Monument, across the Santa Cruz River. A small area is north of Tubac, and several lie nearly north of Calabasas and between that place and Santa Cruz School on the upper river.

SOILS OF THE GILA SERIES

Soils of the Gila series, as occurring in the Nogales area, range in color from brown to dull brown or light grayish brown in their surface soils, and the subsoils are of similar color. They are slightly darker than the typical Gila soils of previous surveys, and in some places layers of dark-brown material are interstratified with the more typically colored Gila material. Both surface soil and subsoil are highly calcareous in most places, which contributes to the grayish-brown color. Soils of the Gila series are similar in profile and occurrence to the Pima soils, from which they are distinguished by their lighter-brown color and somewhat lower organic-matter content.

Gila fine sand.—The surface soil of Gila fine sand to a depth ranging from 10 to 13 inches is loose grayish-brown or dull-brown fine sand. The subsoil to a depth ranging from 60 to 72 inches is more or less stratified fine sand or sand, which is light grayish brown or duller brown in color and is loose and porous. In places the depth of fine sand exceeds 72 inches, and in other places the subsoil is underlain by coarse gravel and cobbles that may be within 3 feet of the surface.

The majority of Gila fine sand is used only for pasture and is covered by grasses and mesquite brush. The sandy loose character of the soil is usually such that the large quantity of water required

and the difficulty of applying it make the land uneconomical to farm under irrigation.

The principal occurrence of this soil is near Santa Cruz River and in tributary washes and valleys. In a few places, near the river and lower than the adjoining soils, pecan trees are being set out on this soil.

Gila fine sand occurs along Santa Cruz River most of the distance from Calabasas to the northern boundary of the area and up Sonoita Creek east of Calabasas. The areas are broken by other soil types in a number of places, but they follow the Santa Cruz River bed fairly closely and, in general, are only separated from the river bed by river wash which lies at a lower elevation than Gila fine sand. Most of the Gila fine sand areas are lower lying than the heavier-textured soils of the same or related series.

Gila sand.—To a depth ranging from 9 to 11 inches Gila sand consists of light-brown or light grayish-brown calcareous medium sand or coarse sand of very loose consistence. Below the surface soil and continuing to a depth ranging from 30 to 36 inches the material is loose coarse sand containing some slightly calcareous fine gravel. Underneath this material is a dark-brown stratified sandy loam or sand layer similar to the subsoils of the Pima soils. This is not typical of Gila sand but represents a deposit of Gila sand over Pima material. As mapped, some of the soil has a brown sand or coarse sand subsoil, instead of the dark-brown sandy loam.

Gila sand occurs at intervals along Santa Cruz River, from Calabasas to the northern boundary of the area, and in a wash northeast of Nogales. Most of it is developed as a narrow strip along the river and lies slightly higher than river wash but lower than the heavier soils in the river bottom. The land is used only for pasture and is covered with bushes and grass.

Gila very fine sandy loam.—The upper 10 to 12 inch layer of Gila very fine sandy loam is calcareous grayish-brown or dull-brown very fine sandy loam which is loose and fairly porous. Beneath this layer is grayish-brown or dull-brown loose calcareous stratified fine sand and sand overlying a loose bed of gravel and cobbles at a depth of 66 or more inches.

This soil occurs near Santa Cruz River, adjoining Gila fine sand in many places. The land is level and easily prepared for irrigation. It lies from 15 to 25 feet above the river. The quantity of water required to produce crops is rather high, owing to the loose consistence and the high sand content. By some farmers it is considered the most desirable alfalfa soil in the area. It produces two tons of hay an acre at each cutting, which is more than the yields of the heavier-textured Gila and Pima soils.

The largest area lies north of Chavez. Smaller areas are west and north of Amado, near Tubac, and north of the Tumacacori National Monument.

A number of small undifferentiated areas of Gila sandy loam are included with Gila very fine sandy loam, on account of their small extent. Two areas, comprising about 100 acres each, are 3½ and 4 miles, respectively, north of Tubac east of the river, and an area is 1½ miles northeast of Tubac. A large part of this included soil is covered by a dense growth of mesquite brush. The remainder is mainly in grass, with some land in barley and grain sorghums.

Small undifferentiated areas of Gila silt loam, comprising about 75 acres and lying 3½ miles north of Tubac are also included with Gila very fine sandy loam. Here the surface soil is silt loam and the subsoil also is heavier. The land is more fertile and has better water-holding qualities than the lighter-textured soils.

SOILS OF THE TUMACACORI SERIES

The Tumacacori soils have dark-brown topsoils overlying dark-brown subsoils. The soils where typically developed contain no free lime in any part. They occur in the river bottoms and small washes where the soil has been deposited by colluvial wash during the seasons of rainfall. The surface soil is in general moderately loose, and the subsoil is stratified with different-textured layers that in many places contain various quantities of gravel. The areas are small and have been formed by deposition of sediments from variable stream currents. Consequently these soils are far from being uniform in texture; that is, in the relative amounts of sand, silt, and clay present.

Tumacacori clay loam.—The 10 to 13 inch surface soil of Tumacacori clay loam is dark-brown or dark dull-brown clay loam free of lime and having but little evidence of weathering. It overlies dark-brown or dark dull grayish-brown noncalcareous stratified material ranging in texture from clay loam to gravelly sandy loam. This material may extend to a depth of 6 feet and may be underlain by waterworn gravel and sand. The surface soil is neutral or slightly acid in reaction and the entire profile is typically noncalcareous, but in some places the subsoil gives a mildly calcareous reaction when tested with acid.

The natural vegetation was originally mesquite, cottonwoods, elderberry, willow trees, and squaw bush, together with native grasses, mainly grama and six-weeks grama. Most of the trees and brush have been cleared off and the land put into farm and truck crops, including barley, alfalfa, hegari, milo, corn, lettuce, and spinach. Much of the lettuce grown in the area at present is on this type of soil. The State experiment station recommends a heavy-textured soil, such as this, as the best for lettuce.

The largest areas of typical Tumacacori clay loam are near, west, and south of Otero and along Nogales Wash. Smaller bodies are north and south of Amadoville School, north of Tubac, just north of Tumacacori National Monument, southwest of Calabasas, and along Santa Cruz River near the Mexican border. Part of an area 2 miles south of Otero, near the river, is underlain by loose sand and is not farmed.

Several small areas having dark-gray or dark brownish-gray subsoils highly mottled with rust-brown iron stains, caused by poor drainage resulting from seepage onto flat and broad areas, are included with Tumacacori clay loam in mapping. Areas of poorly drained clay loam, loam, and gravelly sandy loam occur in the narrow wash 2½ miles north of Nogales, west of the highway. Another very small poorly drained area lies east of Santa Cruz River, 1¼ miles north of the international boundary. The main crops grown on this area are barley, hegari, and milo for feeding dairy cattle.

In a side wash along the Santa Cruz River, 2¾ miles northwest of Santa Cruz School, a 40-acre tract of soil with a brown clay loam topsoil overlying a dark-brown or dark grayish-brown subsoil has also been included.

In local intermittent stream washes on the west side of Nogales Wash, 2 and 4½ miles north of Nogales, are several small areas of Tumacacori clay loam which contain much gravel in the topsoil as well as in the subsoil, together with some cobbles 3 or 4 inches in diameter. These areas, which are shown on the map by gravel symbols, are not cultivated.

Tumacacori clay loam, calcareous-subsoil phase.—Tumacacori clay loam, calcareous-subsoil phase has a dark-brown clay loam surface soil extending to a depth ranging from 10 to 13 inches, below which is a dark-brown or dark grayish-brown silty clay loam or clay loam subsoil mottled with light-gray streaks of lime accumulation. A 50 to 60 acre strip lies 1 mile northwest of Santa Cruz School. On this area, grain sorghum has been produced without irrigation. Across the river from this strip is a similar area that has gravel in the surface soil. About 2 miles farther down the river is an area without the gravel. Along the east side of the valley northeast of Tumacacori School is another small area. One-half mile north of Tumacacori National Monument is a 100-acre strip along the river with a dark-brown silty clay loam surface soil overlying a browner calcareous subsoil. Some of this included area is planted to barley, and the remainder is covered by mesquite.

South of the road leading to Chavez from the main Tucson road is a 20-acre flat near the river with a dark-brown clay loam surface soil containing considerable sand, overlying a similarly textured subsoil that is somewhat compact and mottled with gray lime streaks. On a flat a quarter of a mile northwest of Calabasas School is a body comprising 100 or more acres that contains an accumulation of alkali salts. The surface soil is dark-brown clay loam or silty clay loam free of lime to a depth ranging from 6 to 10 inches. Below this the texture is silty clay loam or heavier material which is dark brown or dark grayish brown in color and is mottled and streaked by lime and gypsum and other alkali salts. The soil is poorly drained and contains rust-brown iron stains in the lower part of the subsoil. In places the surface is crusted over with gypsum and alkali salts, and vegetation is practically limited to two kinds of grass. One seems to be a form of saccaton grass and the other probably a similar species (Sporobolus or Muhlenbergia). There are also a few mesquite bushes. The field in which this soil occurs was under cultivation at one time but now the only indications of former agricultural use are a few apple and pear trees growing along the edge where the land is better drained and contains less alkali. Another area of the same character of soil lies 1 mile southeast of Tubac but does not appear to contain so much alkali.

Other soil areas included with the calcareous-subsoil phase of Tumacacori clay loam are in the northern part of the area near Amadoville School and 1½ miles north of Tumacacori National Monument. These areas occur under somewhat more severe desert conditions than other areas of this soil, and they are not cultivated. They support a growth of goat grass and mesquite brush.

Tumacacori sandy loam.—Typically, Tumacacori sandy loam to a depth of 1 foot is dark-brown sandy loam free of lime. It overlies more or less stratified layers of loam, fine sandy loam, and loamy sand, with or without gravel, which extend to a depth ranging from 4 to 6 feet. In many places the stratified layer is underlain by gravel and coarse sand. The subsoil is variable in texture, owing to the fact that it has been deposited by streams of variable velocity and volume in narrow arroyos or canyons. The subsoil is typically noncalcareous but in a few places a little accumulated lime may be present.

The main occurrence of this soil is along the west side of Santa Cruz Valley and Nogales Wash. A few bodies are scattered over the rest of the area in the stream valleys and tributary washes. The small acreage under cultivation is farmed in conjunction with heavier-textured soils and is devoted to barley and sorghums. The light texture renders this land subject to drought, and much of it lies at too high an elevation for the present water supplies obtained by pumping.

The natural vegetation is mesquite, grama grasses, evergreen shrub, and squaw bush.

As mapped, this soil includes small areas of somewhat heavier loam texture and also areas of Tumacacori sandy loam and Tumacacori loam, which contain considerable quantities of gravel. The gravelly areas are indicated on the soil map by gravel symbols. The included areas of loam texture have dark-brown surface soils and subsoils that are free of lime. These areas are east of Amadoville School, south of the school 2 miles along the private road parallel to the main highway, 1 mile northeast of Tumacacori National Monument, and just south of the national monument. A 40-acre tract lies just west of Otero, and a small area is 1 mile south of that place. Paralleling the highway three-fourths mile southwest of Calabasas is a long boot-shaped area. Smaller areas are north and east of Nogales, a mile southwest of Saxton, north of Santa Cruz School on both sides of the river, about 2 miles southeast of Santa Cruz School in the river bend, and along Santa Cruz River near the international boundary.

The included gravelly sandy loam areas have a topsoil consisting of dark-brown sandy loam which contains a high percentage of waterworn gravel and cobbles from 2 to 4 inches in diameter. In most places the material is very loose and porous, ranging from gravelly sandy loam to gravelly loamy sand. Below a depth ranging from 10 to 15 inches the subsoil is dark-brown gravelly sandy loam, gravelly loam, or gravelly loamy sand, which ranges from 4 to more than 6 feet in depth. This deep layer is free of lime. Areas of this gravelly sandy loam inclusion occur along the recent washes issuing from areas of rough broken and stony land marginal to Santa Cruz Valley and Nogales Wash.

Gravelly loam areas included with Tumacacori sandy loam occur mainly in the wash at Nogales and Camp Steven D. Little, and small areas occur west, north, and northwest of Potrero School. Two areas lie up Sonoita Creek and two are three-fourths and 1½ miles south of Calabasas. Several small bodies are northwest and south-

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east of Santa Cruz School, and there is a small area three-fourths mile west of the river on the Mexican boundary.

Tumacacori sandy loam, calcareous-subsoil phase.—The calcareous-subsoil phase of Tumacacori sandy loam where typically developed has a dark-brown or dull-brown rather loose friable noncalcareous surface soil ranging in texture from sandy loam to fine sandy loam. The subsoil varies from that of the typical soil in that it is calcareous, with the lime accumulated in seams and streaks. The texture of the subsoil ranges from loam to sandy loam or loamy sand. The color is dark brown or dark grayish brown.

This soil occurs in a comparatively large body 1 mile south of Amado and in scattered elongated areas along the first two washes entering Santa Cruz River north of the international boundary, one on the east and the other on the west side of the river. The land is in a natural condition, with mesquite and cactus growing in the northern part and mesquite, oak, and grama grasses in the southern part of the area.

Several bodies of the calcareous-subsoil phase have dark-brown gravelly sandy loam or loamy sand surface soils and heavier highly calcareous subsoils of loam or clay loam texture and dark grayish-brown or dark-brown color. One small body of this included soil lies 2¼ miles north of Chavez, and another is 3¼ miles northwest of Santa Cruz School. None of this land is under cultivation, and it is mainly covered by mesquite brush and grass.

Tumacacori silty clay loam.—The upper 10 to 14 inch layer of Tumacacori silty clay loam is very dark brownish-gray or dark dull grayish-brown silty clay loam which is somewhat compact and hard when dry and sticky when wet. Beneath this is a 12-inch layer of fine sandy loam or clay loam which ranges from dark gray to dark brownish gray in color and contains rust-brown and light-gray mottlings caused by poor drainage. Between 2 and 6 feet the subsoil becomes dark-gray plastic clay, some areas containing lighter-textured and lighter-colored strata. This soil tends to be poorly drained and in places contains seepage spots that keep the water table high, so that slightly acid soil conditions have been developed.

Most of this soil occurs along Nogales Wash, where dairying is the main farm industry and the crops grown are barley (for feed and pasture), hegari, milo, and Amber cane. Along the edges of the areas are small bodies of brown sandy loam or loam, which have been deposited over the heavier surface soil of the typical soil. Some such bodies occur in the Santa Cruz Valley near Otero and between that place and the international boundary.

Tumacacori silty clay loam, calcareous phase.—Tumacacori silty clay loam, calcareous phase, has a dark brownish-gray or very dark grayish-brown silty clay loam surface soil containing lime. Below a depth ranging from 12 to 18 inches the material changes to dark-gray clay or heavy clay loam containing a large number of nodules of lime carbonate or concretions from one-eighth to one-fourth inch in diameter. This layer extends to a depth ranging from 30 to 36 inches. Under this the material is more stratified, or banded, light-gray and dark-gray clay and silty clay loam, free of lime or lime nodules, which extends to a depth of 6 feet or more.

The calcareous phase of Tumacacori silty clay loam occurs along the northern part of Nogales Wash, with a few very small areas east

of Nogales, and the land is used for the same crops as typical Tumacacori silty clay loam.

Tumacacori gravelly loamy sand, dark-colored phase.—Typical Tumacacori gravelly loamy sand does not occur in the Nogales area, but it is represented by a dark-colored phase.

The topsoil of this phase is dark dull-brown or dark grayish-brown fine gravelly loamy sand extending to a depth ranging from 15 to 22 inches. Beneath this and continuing to a depth ranging from 30 to 36 inches is the subsoil of richer dull-brown or reddish dull-brown gravelly loamy sand containing a greater quantity of coarse gravel. Below a depth of 3 feet the soil material is light-brown gravelly sand of very loose consistence. The whole soil profile is very loose and porous. The soil occupies alluvial-fan slopes along the edges of the hills and washes bordering Santa Cruz Valley.

The common vegetation is mesquite, false needle grass, and six-weeks grama that grows on sandy soils and is of little value for grazing. None of the land is cultivated.

Small areas of this soil containing stone as well as gravel occur south of Otero on both sides of the valley, south and north of Tumacacori National Monument, and 1 mile south of Tubac. Small included areas free of gravel in the surface soil are 1¼ miles northwest of Otero and along the east bank of Santa Cruz River just north of the Mexican border.

SOILS OF THE COMORO SERIES

Soils of the Comoro series are characterized by brown or rich-brown surface soils and subsoils and, where typically developed, have no lime in any part of the soil profile. The soils are of recent accumulation and occur in the washes and along the streams, in most places adjoining river wash. In texture the soils are generally very sandy, a fine sand or sandy loam predominating. They occur in the upper part of the Nogales area, mainly in places where the rainfall is greatest and the lime has been leached out of the soil to a greater extent than along the lower part of the Santa Cruz Valley.

Comoro fine sand.—The 10 to 15 inch surface soil of Comoro fine sand is brown or dull grayish-brown fine sand underlain by stratified brown sand, fine sand, or sandy loam sediments. The profile is typically noncalcareous throughout, but locally the lower part of the subsoil may contain some accumulated lime. This is an inextensive soil, and very little of it is used for producing crops as most of it occurs in narrow strips along the river, at intervals from the southern boundary of the area to a point north of Tubac. Some of the wide washes also contain this soil.

Comoro fine sand, loose-subsoil phase.—The surface soil of Comoro fine sand, loose-subsoil phase, is dull-brown or brown fine sand or fine sandy loam to a depth ranging from 12 to 24 inches. At this depth the material changes to coarse sand or loose gravel and sand which are stratified and may extend to a depth of 6 feet or deeper. Some of the areas with a fine sand surface soil overlying a coarse sand subsoil are one of about 40 acres 1¼ miles southeast of Tumacacori National Monument, a small area a short distance north of the monument, and a narrow strip a half mile south of the monument across Santa Cruz River. One and three-fourths miles south of Otero are two small areas separated by an area of river wash.

One very small area is 1¾ miles south of Tubac and one containing some gravel is three-fourths mile northeast of that town. An area including about 35 acres is at Silva, and another is west of that town on the west side of the river. West of the river at Calabasas is a larger strip, and one area is 2¼ miles up Sonoita Creek. Small areas occur up Santa Cruz River three-fourths mile and 4 miles southeast of Calabasas. A mile and a quarter southeast of Santa Cruz School are several small areas, and farther up Santa Cruz River are several small areas including a few acres each. An area half a mile east of Santa Cruz School contains a moderate amount of lime.

Areas of included fine sandy loam with a loose subsoil occur three-fourths mile northwest, one-fourth mile north, and 2 and 3¼ miles northwest of Santa Cruz School. One small area lies 2½ miles east of Plomo, and there are two areas 1¼ and 2¼ miles south of Otero, two areas 1 mile southeast of Tumacacori School, and one 1 mile north of the national monument.

Small included areas of fine sand with loose gravel and cobbles in the subsoil occur three-fourths mile north of Amadoville School, 2½ miles north of Tubac, 1 mile and 1½ miles northwest of Otero, and west of the river on the Mexican border.

Comoro sandy loam.—The topsoil of typical Comoro sandy loam is brown or rich-brown sandy loam or fine sandy loam. The subsoil is sandy loam or fine sandy loam which occurs in stratified layers. This soil occurs in small bodies along the streams and in the side washes. The more important areas are three-fourths mile south of Tubac, 1½ miles northwest of Otero, and one-half and 1 mile north of Santa Cruz School. Small areas lie along the river near the Mexican border, along Nogales Wash and the arroyo entering the wash 2 miles north of Nogales, 2½ miles east of Plomo, 1 mile southeast of Tumacacori National Monument, and on the east edge of Tubac.

A number of small areas of Comoro sandy loam, which contain gravel in the surface soil and to some extent in the subsoil, are three-fourths mile north of Tubac, 1¾ miles northwest of Otero, 1 mile northeast of Calabasas, 2½ and 4 miles southeast of Calabasas, and 1 mile south of that place. One very small area is north and several small bodies are southeast of Santa Cruz School.

In a number of soil bodies included in mapping with Comoro sandy loam the surface soil is reddish-brown gravelly sandy loam. It overlies similarly colored calcareous material, which, below a depth of 24 inches, becomes heavier textured and somewhat compact. These included areas occur at higher elevations than the rest of the soil, on fans emerging from rough broken and stony land. An area is at Saxton and a smaller one is one-half mile north of that place. Small areas occur 3½ and 2½ miles north and one-half mile south of Santa Cruz School. One small area is three-fourths mile north of the international boundary, east of Santa Cruz River.

Most of this soil is covered by mesquite, grama, paloverde, cactus, and small shrubs.

Comoro gravelly loamy sand.—Where typically developed the surface soil of Comoro gravelly loamy sand to a depth of 1 foot is brown or light-brown gravelly loamy sand which is loose, porous, and free of lime. The loose porous subsoil ranges from gravelly loamy sand to loamy

fine gravel. The soil occurs in the side washes and is being constantly worked and reworked by intermittent streams.

Comoro gravelly loamy sand occurs in only a few small areas. One is east of the Tucson road along the northern boundary of the area, and others are one-half mile south of Tubac, three-fourths mile northeast of Nogales, and 3½ miles northwest and 1¼ miles southeast of Santa Cruz School. Southeast of Tumacacori National Monument, a 25-acre tract of brown loamy sand free of gravel and overlying a subsoil of finer sand containing streaks of accumulated lime has been included in mapping. South of Otero along the east side of the valley an included strip of gravelly loamy sand contains a large quantity of stones ranging in diameter from 3 to 6 inches. A dense growth of mesquite covers the stony areas as well as most of the remainder.

Comoro gravelly loamy sand, reddish-brown phase.—The reddish-brown phase of Comoro gravelly loamy sand is characterized by a reddish-brown or rich-brown fine gravelly sand or gravelly loamy sand layer from 11 to 20 inches thick. It is underlain by a subsoil which ranges from gravelly sand or fine gravelly sand to fine gravelly sandy loam. An accumulation of lime may be present in the subsoil in some places.

This soil occurs in small washes marginal to the rough broken and stony land areas, along the sides of the valley, and most of the gravel is granitic. The red color of the soil is derived from the red soil of the adjoining rough broken and stony land areas. This soil is widely distributed throughout the area and is most extensive east of Otero. It is not used for agriculture and in most places supports a dense growth of mesquite. The heavy growth is due to seepage and run-off of water from the higher slopes after rains. In some places this gravelly soil is used as road-surfacing material.

SOILS OF THE CAJON SERIES

The Cajon series is characterized by light-colored soils usually of sandy or coarse sandy texture and open structure. The soils are of recent alluvial accumulation and occupy desert washes and alluvial-fan slopes. Both surface soil and subsoil materials range from feebly to decidedly calcareous. The soil profile is characteristically stratified or imperfectly stratified according to intensity and duration of intermittent, or ephemeral, streams which have transported and deposited the soil materials. The soils are, in general, of low water-holding capacity and of little economic importance.

Cajon gravelly sand.—The surface soil of Cajon gravelly sand is highly calcareous light grayish-brown or duller-brown gravelly sand, containing a large quantity of gravel from 2 to 4 inches in diameter. Below a depth ranging from 10 to 13 inches is the subsoil of grayish-brown or dull-brown calcareous gravelly sand or gravelly sandy loam.

This soil occurs on the east side of the valley north of Tumacacori National Monument, extending as far as the northern boundary of the area. It lies along the edge of the rough broken and stony land areas and extends up some of the recent washes emerging from the hills. The material is colluvial, and fresh material is still being washed out from the hills. The soil occupies a loose fanlike slope above the bottoms which are occupied mainly by the Gila soils.

A dense growth of mesquite brush with some goat grass, rabbit bush, barrel cactus, and paloverde trees, covers this soil. No farming is carried on, and the soil is utilized to only a slight extent for grazing.

SOILS OF THE HESPERIA SERIES

The Hesperia soils have light-brown or brown surface soils of low organic-matter content, and they are predominantly sandy and open. The subsoil materials are of slightly lighter color and similar to the surface soils in character or are imperfectly stratified, but they are slightly compacted without appreciably heavier texture. These soils occupy smooth broad alluvial-fan slopes. Where typically developed both surface soils and subsoils are free from appreciable lime.

Hesperia loamy sand.—The surface soil of Hesperia loamy sand is brown or dark-brown loamy sand containing an appreciable quantity of organic matter in the first 10 or 12 inches. Beneath this the soil becomes richer brown, is slightly heavier and slightly compacted to a depth of 3 feet, and may or may not contain gravel. Below a depth of 3 feet the soil changes to a lighter-brown, richer-brown, or reddish-brown gravelly sand containing cobbles from 3 to 6 inches in diameter.

Hesperia loamy sand occurs on benches or terraces along Santa Cruz Valley and Nogales Wash, lying from 40 to 60 feet above the river. Many of the small bodies are separated from other soils by deep canyons. The land is not farmed, as no water is available for irrigation at this height above the river. A fairly dense growth of mesquite, annual needle grass, and six-weeks grama covers the benches occupied by this soil.

Some areas included with Hesperia loamy sand in mapping contain much waterworn gravel in the surface soil. The gravel ranges from one-half to 3 inches in diameter. Some larger stones are also present, and the gravel extends into the subsoil. Gravelly areas occur on terraces along Santa Cruz River and Nogales Wash, north of Nogales, near Potrero School, near Tubac, and in the vicinity of Saxton. Near Santa Cruz School are areas with stones from 3 to 10 inches in diameter embedded in the soil and lying on the surface. One and a quarter miles north of the Mexican border and east of Santa Cruz River is a 15-acre tract which has a heavier surface soil and subsoil than typical, but which contains some gravel in the surface soil.

As mapped in the Nogales area, Hesperia loamy sand includes small areas about 3½ and 4½ miles southeast of Calabasas, in which the surface soil is brown or darker-brown stony sandy loam or gravelly loam overlying stony or gravelly subsoil materials of light texture, containing accumulated lime. This included soil is not representative of typical Hesperia materials which are noncalcareous or which effervesce only feebly and irregularly.

Hesperia loamy sand, compact-substratum phase.—To a depth of 1 foot the compact-substratum phase of Hesperia loamy sand is dark-brown or grayish-brown loose loamy sand containing a low or moderate amount of organic matter. To a depth of 2½ or 3 feet the dull-brown or brown loamy loose sand rests on a brown or light-brown sandy clay loam compact substratum containing much sharp granitic sand. This phase of soil occurs 2 miles north

of the Mexican boundary in the most eastern part of the area on an alluvial fan that consists of outwash from the Patagonia Mountains. The natural covering is a few scattered bellota and blue oaks, mesquite, annual false needle grass, and six-weeks grama. The only use made of this soil is for pasturing cattle.

SOILS OF THE SONOITA SERIES

The surface soil and upper subsoil materials of soils of the Sonoita series are of pronounced reddish-brown, pale-red, or dull-red color and of friable character. The upper part of the subsoil is slightly compacted. At a depth of about 2 feet is the pinkish-red or purplish-red more compact and heavier-textured subsoil. The soil materials are of gritty texture, owing to included sharp mineral fragments of parent granitic or other quartz-bearing rocks. The soils occupy stream terraces and alluvial fans.

Sonoita sandy loam.—The topmost 12 to 18 inch layer of typical Sonoita sandy loam is brown or reddish-brown loose light-textured sandy loam. It is underlain by rich-brown, reddish-brown, or dull-red loamy sand or sandy loam to a depth of 2 feet. Between depths of 2 and 3 feet the soil material becomes more compact, browner, and heavier in texture, being sandy loam or clay loam of higher moisture-holding capacity. This layer, in turn, is underlain by grayish-brown or pinkish-brown clay loam or loam, containing a large quantity of angular fine granitic gravel and sand that give the material a gray appearance when wet.

Sonoita sandy loam occurs on benches or stream terraces, usually from 50 to more than 75 feet above the streams. The surface is in most places undulating and sloping toward the stream bottom. Most of the areas of this soil are small, and at the present time the land is not in cultivation. It is said that many years ago soil of this kind produced pink beans without irrigation in favorable years.

This soil is mapped on the terraces along Santa Cruz River and Nogales Wash. Areas containing gravel and stones in the surface soil and in most places in the subsoil and which are also loose and porous throughout the whole soil profile occur east of Santa Cruz River north of the Mexican boundary. Several gravelly areas also occur 3 miles northwest of Santa Cruz School and 1¼ miles northwest of Potrero School. Several small bodies are 3 miles southeast and 1 mile south of Calabasas. Others lie half a mile north of Calabasas School and east along Sonoita Creek Valley. Small areas of the typical soil occur 2½ miles northwest of Calabasas, 2¼ miles south of Otero, 1 mile northeast of Tumacacori School, 1 and 2 miles north of Tubac, 1½ and 2 miles south of Amado, west of the Tucson road, and south of Amadoville School.

West of Plomo are several included areas of reddish-brown fine gravelly sandy loam soil overlying reddish-brown more compact loam. One such area is 2¼ miles northwest of Calabasas and others are near Santa Cruz School. A few areas lie 1⅛ miles south of Potrero School.

Included with Sonoita sandy loam are some areas of soil with a rich-brown loamy sand or loamy gravelly sand surface soil overlying a very calcareous gravelly loam or gravelly sandy loam subsoil. Areas of this calcareous inclusion are 1 mile northeast of Amado, 1½ and 2 miles south of Amado, 1 mile northeast of Tuma-

cacori National Monument, and 1½ miles north of the international boundary along the eastern boundary of the Nogales area.

SOILS OF THE TUBAC SERIES

Soils of the Tubac series have pronounced reddish-brown, red, or dull-red surface soils which are usually friable. They are underlain very abruptly by very compact, tough, waxy clay or sandy clay loam material of columnar structure, which becomes less impervious and of lighter texture with increasing depth and grades into stony, gravelly, or sandy materials of lighter-gray color and high lime accumulation, in places cemented into layers or irregular lenses of lime cementation or caliche.

The Tubac soils occupy old elevated alluvial fans and desert plains. The surface is smooth and sloping but somewhat eroded and gullied in places. Where undisturbed it is covered in many places with a desert pavement of waterworn pebbles and stones. These soils support a vegetation of desert shrubs, cacti, and, where not overgrazed, desert grasses.

Most of the areas lie at an elevation above sources of water supply for irrigation, the surface soil is shallow in many places, and the soils are of little economic importance except for scant grazing.

Tubac gravelly sandy loam.—The 5 or 6 inch surface soil of Tubac gravelly sandy loam is dark reddish-brown noncalcareous gravelly sandy loam. In most places the surface is covered with a large quantity of stones from 6 to 12 inches in diameter, together with much gravel. Between depths of 6 and 20 inches the subsoil is dark reddish-brown or dull-red, very tough, compact columnar clay containing some lime in the lower part. Below a depth of 20 inches the material is grayish brown changing to light gray, owing to a high content of lime, and it ranges in texture from silt loam to gravelly sandy loam, in many places cemented into a lime-carbonate hardpan.

Tubac gravelly sandy loam occurs on the west side of Santa Cruz Valley, from Tubac to the northern boundary of the area. None of this soil is under cultivation. One-fourth mile north of Tubac is an area with a gravelly surface soil free of the larger stones. Here the surface soil is reddish-brown clay instead of dark-brown sandy loam. Mesquite, a resinous shrub, and goat grass grow on this soil, with paloverde and a few cacti of different species.

SOILS OF THE NOGALES SERIES

The surface soils of the Nogales soils are red and in most places friable. They are underlain by heavy-textured compact subsoils of similar or more pronounced dull-red color. The subsoils grade into lighter-red materials containing small, sharp, angular fragments of parent rock. The Nogales soils are developed on consolidated bedrock of granite, volcanic tuffs, and arkose sandstone, and are conglomerate in character. They occupy rolling or hilly and dissected areas. Surface drainage is well developed in most places, but subdrainage is restricted by the compact heavy-textured subsoil in the flatter areas. The deeper part of the subsoil and the partly weathered bedrock substratum contain seams of limy material. The soils are for the most part unirrigated and are utilized only for grazing.

They support a vegetation of stunted oaks, yucca, mesquite, and other shrubs, and grama and other grasses.

Nogales clay loam.—Nogales clay loam has developed in place from the underlying weathered rock material and has a 2 or 3 inch surface soil of dark dull-red sandy loam. Beneath this thin layer, which in places may be removed by erosion, is a brownish-red heavy compact clay or clay loam layer extending to a depth ranging from 15 to 20 inches, at which depth it changes to lighter reddish-brown clay loam or light clay containing small angular fragments of the granitelike rock that lies under it at depths ranging from 2½ to 3½ feet.

This soil occurs on the hills and upland areas between Nogales Wash and Santa Cruz River and north along Santa Cruz River. Some of the soil areas included in mapping have developed from elevated terrace material of unconsolidated character and have a substratum of gravel and sandy material. The areas east of Santa Cruz River near the international boundary and south of Santa Cruz School have a large quantity of stone on the surface and throughout the soil.

As mapped, Nogales clay loam also includes small areas having a dark-brown stony clay loam or silty clay loam surface soil overlying a lighter-brown clay subsoil. Such areas occur 1½ miles northwest of Calabasas, in small areas east of Nogales north of the international boundary, and 1 mile north of the border east of Santa Cruz River, and some areas without stones or gravel in the surface soil lie 1¾ miles north of the Mexican line in the most eastern part of the area and 1 mile southeast of Santa Cruz School along the hills. Nogales clay loam is not generally cultivated, although some grain sorghum is being grown, without irrigation, on some of the land.

MISCELLANEOUS SOIL MATERIALS

River wash.—River wash consists of sandy and gravelly areas along Santa Cruz River and in the side washes that are too loose, porous, sandy, and gravelly to be used for agricultural purposes. They are subject to irregularly recurring overflow and are frequently modified by erosion or by accumulation of material at each rainy season. Much of the land is bare of vegetation, although some of it is partly covered by an evergreen shrub. Material from some of the areas of river wash is used in road building and other construction work.

Rough broken and stony land.—Rough broken and stony land occupies a broad area between Santa Cruz River and Nogales Wash and along both sides of the stream valleys from one end of the Nogales area to the other. It consists mostly of areas of rough broken relief. Much of the land is of stony character or broken by rock outcrop. Included areas of shallow soil are recognized as undifferentiated soils of the Nogales series. The land is used for grazing cattle and goats and is covered with an annual six-weeks grass, hairy grama, side-oats grama, and mesquite, especially in the lower washes, yucca, bellota oak, and blue oak. North of Tubac the vegetation includes several types of cacti, ocotillo, goat grass, and paloverde, instead of the grama and six-weeks grass, which grow at higher elevations in the southern part of the area.

Owing to unfavorable or prohibitive relief, shallow or stony soils, and its occurrence above sources of water supply for irrigation, this

land is of no agricultural significance save for its value for grazing purposes.

ALKALI

During the course of the soil survey of the Nogales area, injurious accumulations of alkali salts were found in two small areas, one 1 mile northwest of Calabasas and the other 1 mile southeast of Tubac. Both areas are poorly drained and have a high water table. The salts, which are apparent on the surface in most places as an efflorescence, or crust, are mostly gypsum, calcium sulphate, and calcium, magnesium, and sodium chlorides, sulphates, and bicarbonates. There is no black alkali or sodium carbonate present, as determined by chemical analyses.

The areas containing injurious quantities of alkali are occupied by Tumacacori clay loam, calcareous-subsoil phase, Pima fine sandy loam, and Pima silt loam. These soils are impregnated with gypsum, especially in the subsoil, where it is plainly visible.

The total quantity of alkali and gypsum is nowhere more than 10,000 parts per million, or 1 per cent. The kind and quantity of the salts are such that they can be removed by drainage and washing out where drainage conditions are favorable. The alkali accumulations occur, however, in local low flat areas, and artificial drainage to the stream channel or other feasible outlet will be necessary before the soils can be reclaimed and rendered fit for cultivation.

Samples of a number of alkali-affected soils of the Nogales area were sent to the University of Arizona where chemical analyses were made. The results of these analyses are given in Table 3.

TABLE 3.—*Chemical analyses of alkali salts of soils examined in the Nogales area, Arizona*

[Parts per million]

Soil	Location and condition	Depth	Total soluble salts	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Chlorides (Cl)	Sulphates (SO_4)	Carbonates (CO_3)	Bicarbonates (HCO_3)
		Inches								
Tumacacori clay loam, calcareous - subsoil phase.	1 mile southeast of Tubac; poorly drained; water table below 3 feet.	0–12	4,565	105	37	1,334	250	2,400	0	439
		12–36	6,599	2,437	131	0	260	3,600	0	171
		36–72	4,020	75	22	1,153	110	2,250	0	415
Do	1 mile northwest of Calabasas; poorly drained; salts on surface.	0–12	7,802	2,362	187	0	560	4,400	0	293
		12–36	9,294	3,375	225	0	90	5,380	0	244
		36–72	7,693	75	94	2,271	70	5,000	0	183
Do	1¼ miles northwest of Calabasas; white alkali salts on surface.	0–12	4,789	1,030	0	436	200	2,940	0	183
		12–36	8,807	2,850	244	0	130	5,400	0	183
		36–72	1,628	75	94	202	50	900	0	232
Pima loam	¾ mile southeast of Tumacacori National Monument; edge of barley field; trace of salts from irrigation water.	0–12	1,511	180	52	210	150	675	0	244
		12–36	412	60	7	50	80	0	0	220
		36–72	1,003	75	45	160	70	385	0	268
Pima fine sandy loam	1¾ miles northwest of Calabasas; salts on surface.	0–12	4,634	30	0	1,442	140	2,400	0	622
		12–36	1,284	15	7	363	110	240	0	549
		36–72	589	30	0	146	70	50	0	293
Pima silt loam	At Calabasas near railway station; grass cover; has been cultivated; no sign of alkali salts.	0–12	666	135	90	0	60	100	0	281
		12–36	527	45	30	61	60	50	0	281
		36–72	365	30	0	75	40	0	0	220
Nogales clay loam [1]	1½ miles northwest of Calabasas.	0–12	407	105	37	0	60	0	0	207
		12–36	554	75	82	0	60	130	0	207
		[2] 36–72								

[1] Not typical of Nogales series.

[2] No samples taken at this depth.

The areas of excessive or injurious salt accumulation are indicated on the soil map. These are inclosed within red boundary lines and indicated by the symbol "A" in red. The concentration of total salts, as determined by analysis, is shown in the form of a fraction in terms of parts of total salts per million. The number above the line indicates the salt content of the soil to a depth of 1 foot, and the number below the line shows the average salt content to a depth of 6 feet, except in Nogales clay loam, a shallow soil, in which the sample extends to a depth of only 2 feet.

SOILS AND THEIR INTERPRETATION

Only two soils of the Nogales area exhibit an advanced profile development—the Nogales and the Tubac soils. In both these soils a heavy-textured and compact horizon of illuviation has been developed. A rather incipient development of an illuviated horizon is represented in the less mature Sonoita sandy loam. All these soils are of low organic-matter content, oxidation has progressed to an advanced degree under environmental conditions of low rainfall and high temperatures, and most of them range from pale reddish brown or pronounced reddish brown to dull red or dark red in color. The regional characteristics of the Nogales area from the point of view of mature soil development are probably correctly ascribed to those of the red, or southern desert, region in which the soils are dominantly of pale-red or red color and are related to the soils of the red desert steppes of the Russian school of soil classification.

The arable soils of economic importance, however, are of recent deposition and unweathered character or represent only very young or immature stages in development. They occupy stream bottoms, stream terraces, and alluvial fans. Some of these soils, particularly those of alluvial-fan accumulation, are of low organic-matter content and of light grayish-brown or light-brown color, as the Cajon soils; others, which constitute the important agricultural soils of the area, occur only in the stream bottoms and are of comparatively high organic-matter content and medium-brown or dark dull grayish-brown color, as the soils of the Pima, Comoro, and Tumacacori series.

The dominant natural vegetation is a characteristic desert vegetation of mesquite, yucca, desert grasses, cactus, ocotillo, and paloverde. On the residual Nogales soil developed on consolidated rocks in the southern part of the area, mesquite, yucca, annual six-weeks grama, hairy grama, and side-oats grama constitute the main plant growth, together with a few bellota oak and blue oak trees. On the loose gravelly and sandy soils of the terraces and alluvial fans adjacent to the stream valleys the vegetation is mainly mesquite, with some annual false needle grass and six-weeks grama. At the northern end of the area, where the elevation is lower and the rainfall and temperature higher, goat grass and cactus, of the pricklypear, cholla, and barrel varieties, paloverde, and a resinous shrub (*Haplopappus hartwegi*) prevail. The recent-alluvial bottom soils not under cultivation support a dense growth of mesquite, with less amounts of cottonwood, common river-valley willow, Arizona blue

elderberry, squaw bush, an evergreen shrub (*Senecio saligna*), and several varieties of grama. Unlike some of the lower-lying desert areas there is little or no creosote bush, ironwood, or giant cactus, owing to the low winter temperature.

The soils are formed mainly from materials derived from arkosic and tuffaceous conglomerates and sandstone (occurring between Nogales Wash and Santa Cruz River), schist, gneiss, and basalt. The fine disintegrated fragments from the rocks have been mixed with the finer soil material and have caused a large proportion of the soils to be high in content of sand and gravel.

The Nogales soils are brownish-red or dark dull-red soils developed in place on granitelike rocks and arkose and tuffaceous conglomerates and sandstones. In most places these soils have weathered to only a slight depth, and, as they are without water supply, they are of little economic importance except for grazing. They are represented in this area by a single soil type, Nogales clay loam.

The topmost 2 or 3 inches of soil, representing the A horizon, is dark dull-red sandy clay loam, in many places of light texture, approaching sandy loam, and containing some fine gravel. The material is somewhat granular, with a tendency toward a platy structure. In many places this thin surface layer has been removed by erosion, and the surface may be covered by a layer of stones ranging from several inches to a foot in diameter. The B_1 horizon, which extends to a depth of 8 inches, is brownish-red or dull-red heavy compact clay with a columnar structure. This grades into a B_2 horizon of brownish-red or lighter-red more compact clay which contains some unweathered fine angular parent rock material. It also is columnar in structure. It extends to a depth of about 14 inches and grades into light reddish-brown clay or clay loam which is columnar in structure and contains partly weathered rock fragments. This horizon contains some lime, whereas the horizons above are lime free. The C_1 horizon, extending from about 21 to 30 or more inches, is light-red clay loam containing partly weathered parent rock material high in quartz fragments and with calcareous seams. This soil occurs mainly in small scattered areas on the upland between Nogales Wash and Santa Cruz River, and it is not farmed to any extent.

The Nogales soils have not been recognized in previous soil surveys. They seem to be most closely related to soils of the Fallbrook series of the southern California coastal region. They are, however, developed at higher altitudes and under somewhat more pronounced desert conditions, are more maturely weathered than the Fallbrook soils, and unlike the Fallbrook are distinctly calcareous in the deeper part of the weathered material, or solum, and in the partly weathered parent rock.

The Tubac soils are somewhat similar to the Mohave soils which are widely developed in the southern desert region and have been extensively mapped in contiguous southern Arizona areas. They occur on older and more elevated desert plains and alluvial-fan slopes, and their physiographic relationship as well as certain characteristics in color and soil profile indicate them to represent a some-

what more mature development than the Mohave soils, though this may be owing to the fact that they appear to have developed under slightly higher rainfall and at slightly greater elevation than the Mohave soils. They are probably much less extensive than the Mohave soils and in this area are represented by a single type, Tubac gravelly sandy loam.

In a locality where this soil is typically developed, the topmost 5 or 6 inches of Tubac gravelly sandy loam is dark reddish-brown gravelly sandy loam containing a large quantity of stones from 4 to 12 inches in diameter, most of which are on the surface. The soil material is fairly loose and slightly granular, with a neutral or slightly acid reaction. This layer is underlain abruptly by a B_1 horizon, extending from 5 to 12 inches, of dark reddish-brown plastic compact clay or sandy clay with a columnar structure, the tops of the columns being rounded. The layer is free of lime. The next layer is rich-brown or light-brown clay of less pronounced columnar structure, slightly more friable, and slightly calcareous. It extends to a depth of 20 or 22 inches. The B_3 horizon, extending from 20 to 36 inches, is light grayish-brown loam streaked with gray lime accumulations. This horizon is highly calcareous, compact, has a columnar structure, and contains some gravel. The material below this to a depth of 44 inches is light grayish-brown or brownish-gray loam or clay loam which is very calcareous, with gray streaks of lime, and compact. The structure is vesicular. Below a depth of 44 inches the material is light-gray gravelly sandy loam or gravelly loam. It is compact and very calcareous, in places very heavily cemented into a gravelly hardpan. It is massive and structureless. The profile is of pronounced solonetz character. This soil lies above source of water supply and is not used for agriculture.

The Sonoita series of soils, which, like the Tubac and Nogales series, is a newly recognized series of soils represented in this area by a single soil type, a much less maturely developed soil. It represents a younger stage in weathering than the Mohave soils and has been developed at higher altitudes and under somewhat greater rainfall and vegetative environment, transitional between the desert-shrub and desert-grassland types of vegetation.

Where typically developed the 2½-inch surface layer of Sonoita sandy loam is reddish-brown or dark-brown sandy loam of loose consistence and single-grained structure. The A_2 horizon between depths of 2½ and 14 inches is rich-brown or reddish-brown sandy loam or loamy sand, loose, and with a somewhat granular structure. The B_1 horizon, from 14 to 24 inches, is similar to the horizon above in color and is a sandy loam or loamy sand, not quite so loose. The B_2 horizon, from 24 to 30 inches, is rich reddish-brown compact fine sandy loam with a vesicular structure. Some fine gravel occurs in this horizon. The C horizon, from 30 to more than 36 inches, is compact rich-brown, grayish-brown, or pinkish-brown clay loam with a vesicular structure and a large proportion of pore space. Coarse sand and fine gravel are mixed with the finer material. The 2½-inch surface layer is slightly acid in reaction, whereas the rest of the surface soil and the subsoil are neutral or slightly alkaline. The substratum contains a trace of lime.

Results of hydrogen-ion determinations made in the laboratories of the University of Arizona of a sample of Sonoita sandy loam represented by the profile described above are as follows:

Depth in inches	pH
0 – 2½	6.85
2½–14	7.50
14 –24	7.65
24 –30	7.85

Soils of the Pima and Gila series are closely related unweathered recent-alluvial soils occurring mainly on the flood plains along the larger streams. The soils of both series are calcareous throughout the profile and differ from one another in color only. The Pima soils are dark-colored and the Gila light-colored brown or grayish brown. Pima silt loam has a dark dull-brown or dark grayish-brown more or less loose surface soil, with a trace of a vesicular structure to a depth of 12 inches. The subsoil to a depth of 48 inches is similar-colored calcareous stratified material ranging in texture from silt loam to sandy loam. Some signs of a vesicular structure are present. Streaks of slight lime accumulation are common in this part of the profile. The lower part of the profile is in general lighter textured, ranging from loam to sand, and in some places sand and gravel is present at a depth of less than 72 inches. The material here is highly calcareous and loose. On account of the small soil areas due to the narrow valley in which they occur, the soils are badly mixed, and noncalcareous strata are not uncommon in the Pima subsoils.

Gila fine sand to a depth of 12 or 14 inches is grayish-brown calcareous fine sand. The subsoil to a depth of 72 inches is similar-colored stratified calcareous fine sand or fine sandy loam. The whole profile is loose in the fine sand type but may show very slight compaction and a vesicular structure in the heavier-textured soils. The Gila and Pima soils are the most important soils in the Nogales area from the point of view of agriculture.

Soils of the Tumacacori and Comoro series are dark-brown and light-brown noncalcareous soils, respectively, that are equivalent to the Pima and Gila soils except in the absence of lime in their profile.

Tumacacori sandy loam is a recent-alluvial bottom soil occurring along Nogales Wash and Santa Cruz River under similar conditions as the Pima soils. The 12½-inch surface soil is dark-brown noncalcareous sandy loam fairly high in organic matter. It tends toward a single-grained structure. Between 12½ and 30 inches the material consists of stratified sediments ranging from dark-brown sandy loam to fine sandy loam. From 30 to 48 inches the material changes to dull-brown noncalcareous sandy loam or loamy sand overlying a bed of loose gravel in many places. The gravel bed varies in depth. The Tumacacori, Pima, and Gila soils are the main soils under cultivation in the Nogales area.

Comoro fine sand has a 12-inch brown or dull-brown surface soil of loose fine sand. The subsoil to a depth of 6 feet is dull-brown or brown loose stratified sand and fine sand. Typically the profile is free of lime, but as mapped much of it may have traces of lime in the lower part of the subsoil.

The Cajon soils consist of recent alluvial-fan deposits, and no distinct profile, due to weathering, has developed. These soils occur under somewhat more pronounced desert conditions than the other recent-alluvial soils of the area and are mapped mainly in the northern part. Both surface soil and subsoil materials are mildly calcareous. Cajon gravelly sand is the only member of the Cajon series mapped.

The Hesperia soils likewise are represented by a single type, Hesperia loamy sand, with a compact-substratum phase. Typical Hesperia soils are brown or light brown in color, loose, and have sandy permeable subsoils which are but slightly compacted. They represent a very young stage in soil weathering. As occurring in the Nogales area they are of slightly darker color and higher organic-matter content than the Hesperia soils mapped in previous surveys.

The surface soil of Hesperia loamy sand is rather rich brown or dark-brown loamy sand containing appreciable organic matter and much fine granitic gravel. The structure of the 13-inch surface soil is slightly granular. The subsoil from 13 to 22 inches is rich-brown or dull-brown sandy loam or loamy sand, containing waterworn gravel and fine gravel. It is slightly granular and loose but with a trace of compaction. The subsoil between depths of 22 and 34 inches is rich-brown or reddish-brown gravelly sand, also loose and porous, or fine sandy loam, mixed with many cobbles from 2 to 4 inches in diameter. From a depth of 34 to more than 60 inches the substratum is light-brown or reddish-brown loose porous fine gravelly sand containing some lime. The surface soil is noncalcareous, but the subsoil contains a trace of lime. The soil is formed from material eroded from the higher ridges and hills and deposited by stream action.

The Hesperia, Sonoita, and Cajon soils are not under cultivation but are mainly covered by mesquite and grasses, principally annual false needle grass and six-weeks grama. Beans are said to have been grown on the Sonoita soils without irrigation in seasons of high rainfall.

Results of hydrogen-ion determinations, made in the laboratories of the Bureau of Chemistry and Soils at Washington, of some of the representative soil samples of the Nogales area are given in Table 4. The hydrogen-electrode method was used in the determinations.

TABLE 4.—*pH determinations of soils in the Nogales area, Arizona*

Sample No.	Soil type	Depth	pH	Sample No.	Soil type	Depth	pH
		Inches				*Inches*	
511213	Hesperia loamy sand	0–13	7.29	511248	Tubac gravelly sandy loam	44–72+	8.10
511214	do	13–22	7.59	511256	Nogales clay loam	0–2½	7.19
511215	do	22–34	7.83	511257	do	2½–8	6.43
511216	do	34–60+	8.50	511258	do	8–14½	7.05
511243	Tubac gravelly sandy loam	0–5	7.42	511259	do	14½–21	8.50
511244	do	5–12	7.77	511260	do	21–30+	8.72
511245	do	12–20	8.71	511270	Tumacacori clay loam	0–11	7.32
511246	do	20–36	8.57	511271	do	11–72	7.39
511247	do	36–44	7.75				

SUMMARY

The Nogales area is in the western part of Santa Cruz County in the southeastern part of Arizona. It includes the Santa Cruz River Valley and the valley of Nogales Wash, as well as the territory between them, with some bench land and areas of rough broken and stony land along both sides of the valleys extending from the Mexican boundary to the northern boundary of the county. The area covers 97 square miles.

The comparatively flat stream valleys, which are from ¼ to 1¼ miles wide, constitute the main farming section of the area and are from 3,100 to 3,700 feet above sea level. Mesquite is the most common natural vegetation. It grows in all parts of the area and cottonwood, Arizona blue elderberry, and common river-valley willow grow in the valleys. The native grasses are hairy grama, side-oats grama, six-weeks grama, annual false needle, and saccaton. Owing to more desertlike conditions, goat grass is the most common grass in the northern part of the area, associated with a few barrel cacti and ocotillo and paloverde trees.

The climate is dry and hot in the summer and fairly mild in the winter. The minimum and maximum temperatures for the year are 10° and 110° F., respectively. The mean annual rainfall at Nogales is 14.19 inches, the greater part of which falls during July, August, and September.

The main crops grown in the valley are barley for hay, grain sorghums, corn, alfalfa, beans, cotton, lettuce, and other vegetables. A small quantity of fruit, as apples, peaches, plums, and pears, is grown for local use. Much land in the area is undeveloped and could be cultivated to any of the crops grown. The climate is cooler than in the main lettuce-producing areas of the State. This makes the Nogales area a desirable place in which to grow the crop when lettuce from the other areas is out of the market. The State experiment station recommends that the acreage devoted to lettuce and cotton be increased. Corn and sorghums are recommended as silage crops on the dairy farms.

The main soils in the valleys are Pima fine sandy loam, Pima silt loam, Gila fine sand, Gila very fine sandy loam, Tumacacori clay loam, Tumacacori sandy loam, and Tumacacori silty clay loam. The tendency is to produce most of the crops, except alfalfa and pecans on the heavier-textured soils. Pecans are grown on Pima fine sandy loam and Gila fine sand.

The terrace and alluvial-fan soils of the Hesperia, Sonoita, and Cajon series are, in general, loose, porous, and sandy or gravelly. At present they are not farmed. Other unimportant soils occur on the hills and are included in the Nogales series.

The agriculture of the area is carried on under irrigation on the better soils in the valley. Water is obtained mainly by pumping, and some is obtained from Santa Cruz River by gravity flow. In time past the terrace soils were irrigated by ditches and farmed to some extent. The lowering of the river channel is said to have put the ditches out of use.

○

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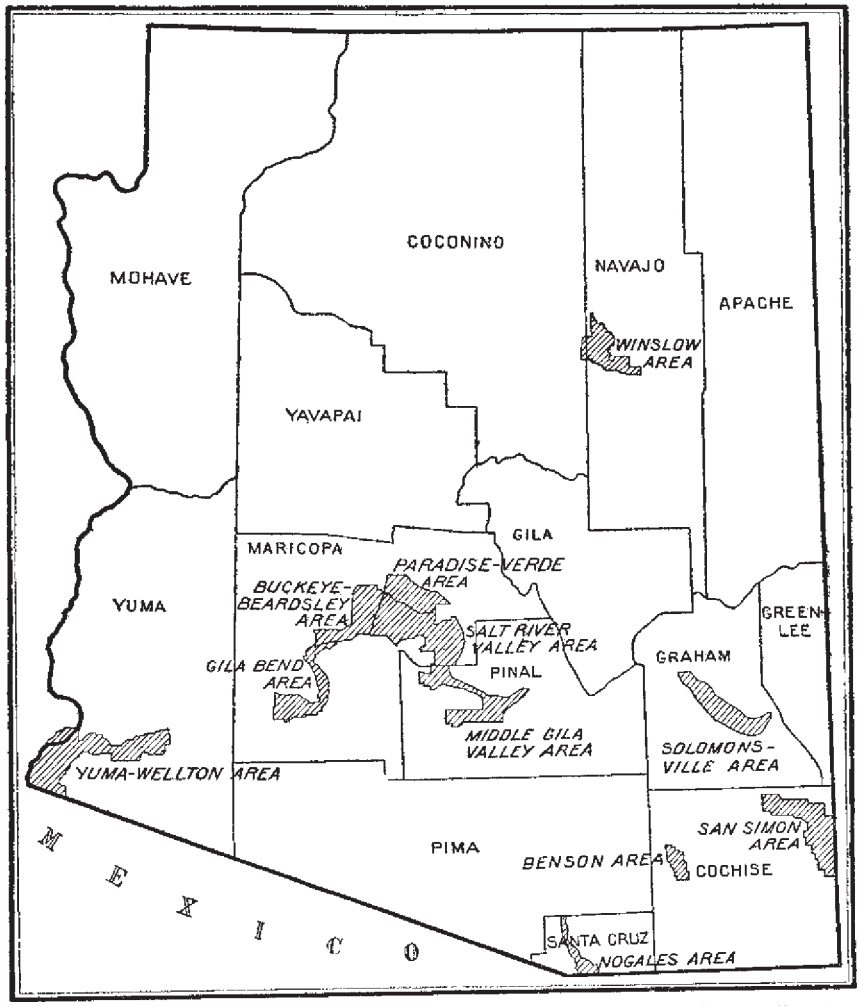

Areas surveyed in Arizona shown by shading. Detailed surveys shown by northeast-southwest hatchings

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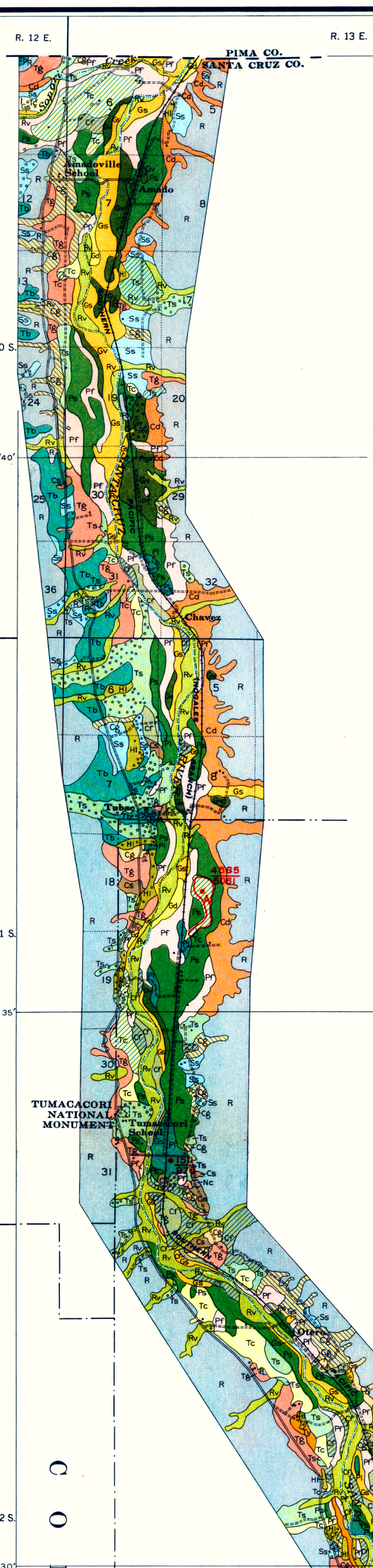
SOIL MAP
NOGALES AREA
ARIZONA

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
P. S. BURGESS, DIRECTOR
W. T. McGEORGE, HEAD, DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS



CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort.

Secondary roads and Trails

Railroads Steam and Electric

Bridges, Ferry

R.R. crossings, Tunnel

Ford, Dam

School or Church Cemeteries

Mine or Quarry Mine dumps Made land

Bluff, Escarpment Rock outcrop and Triangulation station

Stony and Gravelly areas

Soil boundaries

Boundary lines

Boundary lines

Boundary lines

U.S. township and section lines

DRAINAGE
(Printed in blue)

Streams

Lakes, Ponds, Intermittent lakes

Intermittent streams

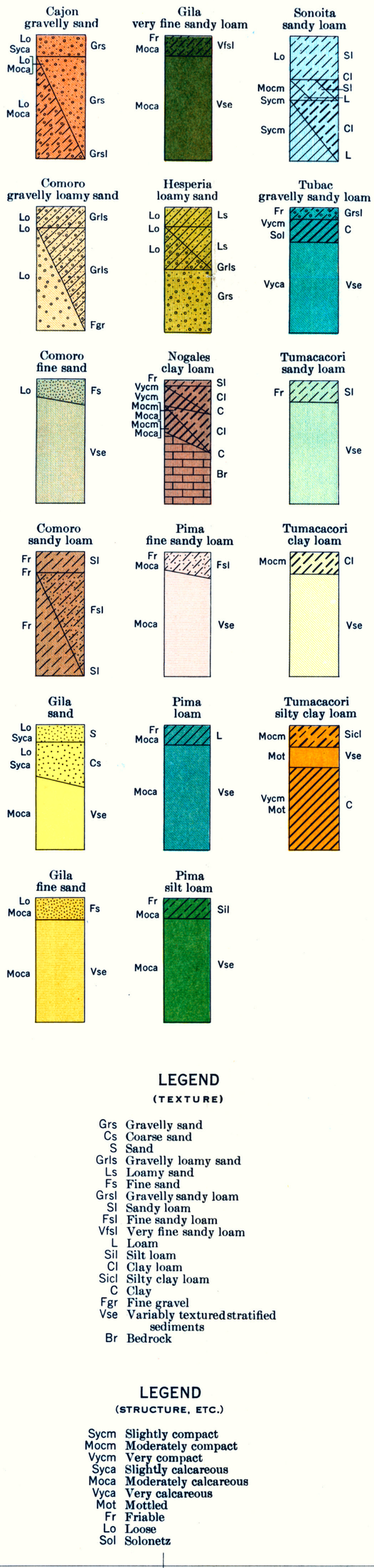
Springs, Canals and Ditches, Flumes

Swamp Salt marshes

Submerged marsh Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

TYPICAL PROFILE DIAGRAMS
(6 feet deep)



LEGEND
(TEXTURE)

Grs	Gravelly sand
Cs	Coarse sand
S	Sand
Grls	Gravelly loamy sand
Ls	Loamy sand
Fs	Fine sand
Grsl	Gravelly sandy loam
Sl	Sandy loam
Fsl	Fine sandy loam
Vfsl	Very fine sandy loam
L	Loam
Sil	Silt loam
Cl	Clay loam
Sicl	Silty clay loam
C	Clay
Fgr	Fine gravel
Vse	Variably textured stratified sediments
Br	Bedrock

LEGEND
(STRUCTURE, ETC.)

Sycm	Slightly compact
Mocm	Moderately compact
Vycm	Very compact
Syca	Slightly calcareous
Moca	Moderately calcareous
Vyca	Very calcareous
Mot	Mottled
Fr	Friable
Lo	Loose
Sol	Solonetz

LEGEND

Cajon gravelly sand — Cd
Pima fine sandy loam — Pf
Comoro gravelly loamy sand — Cg
Reddish-brown phase
Pima loam — Pl
Pima silt loam — Ps
Comoro fine sand — Cf
Loose-subsoil phase
Sonoita sandy loam — Ss
Tubac gravelly sandy loam — Tb
Comoro sandy loam — Cs
Tumacacori gravelly loamy sand, Dark-colored phase — Tg
Gila sand — Gd
Gila fine sand — Gs
Tumacacori sandy loam — Ts
Calcareous-subsoil phase
Gila very fine sandy loam — Gv
Tumacacori clay loam — Tc
Hesperia loamy sand — Hl
Calcareous-subsoil phase
Tumacacori silty clay loam — Ty
Compact-substratum phase
Nogales clay loam — Nc
Calcareous phase
River wash — Rv
Rough broken and stony land — R

High average concentration of alkali — A

NOTE: *Location of borings and result of field tests in parts per million shown thus:* • 478g / 5075
The upper figure shows the concentration in the surface foot.
The lower figure shows the average concentration to the depth of six feet, except in the case of Nogales clay loam, which is to the depth of 2 feet.

Macy H. Lapham, Inspector, District 5.
Soils surveyed by T. W. Glassey.

1 ½ 0 1 2 3 4 Miles
Scale 1 inch-1 mile

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Field Operations
Bureau of Chemistry and Soils
1930